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AN EVALUATION OF SYSTEMS FOR HARVESTING GRAPEFRUIT IN TEXAS

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This report describes research to find less costly and more efficient systems of handling fresh citrus fruits by describing operations and packing plant costs for various systems of harvesting citrus in Texas.

This research was conducted in the Lower Rio Grande Valley. It is part of a broader program of ARS research to develop systems that will reduce the costs of distributing agricultural products.

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An Evaluation of Systems for Harvesting Grapefruit
in Texas

By

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Summary

Costs to the packing plant for three basic systems of harvesting and handling grapefruits in Texas were developed. Two methods of crew payment--contract and (synthesized) plant-employed--were used in calculating the costs to the packing plant for the various systems. The three basic systems include citrus harvested and handled in pallet bins, bulk trucks, and field boxes. Models were constructed to reflect costs for harvesting, transporting, and unloading representative loads by each of the six systems (3 basic systems X 2 methods of crew payment).

The bulk truck and field box contract systems had harvesting costs of \$12 per ton which is the prevailing contract price for harvesting expected in Texas for the 1974-75 season. In the pallet bin system, the packing plant provided a forklift-equipped tractor for use in the field by the contract harvester at a cost slightly higher than our calculated cost so that its harvesting cost was \$11.92 per ton.

The field box systems had labor and equipment costs for handling the harvested fruit at the plant at \$4.91 per truckload or \$0.67 per ton. The pallet bin systems had labor and equipment costs at the plant of \$3.33 per truckload or \$0.39 per ton. The bulk truck systems had the lowest costs, \$1.72 per truckload or \$0.19 per ton.

1/ The authors--all in the Market Operations Research Laboratory, Agricultural Marketing Research Institute, Northeastern Region--are respectively, agricultural economist, industry economist and industrial engineer.

Of the contract systems, the bulk truck system had the lowest total system cost at \$12.19 per ton. The pallet bin system and the field box system had total system costs of \$12.31 and \$12.67 per ton, respectively.

Of the synthesized plant systems, the bulk truck system had the lowest total system cost of \$10.10 per ton, with the lowest harvesting labor costs of \$7.47 per ton and the lowest harvesting equipment costs at \$2.44 per ton. The pallet bin system had total system costs of \$12.03 per ton with labor costs of \$7.97 per ton and equipment costs of \$3.67 per ton. The field box system had total system costs of \$12.54 per ton with labor costs of \$8.23 per ton and equipment costs of \$3.64 per ton. Costs at the plant were the same per ton for these systems as for the contract systems.

INTRODUCTION

The citrus industry in Texas is primarily located in three counties in the Lower Rio Grande Valley: (1) Hidalgo County with about 85 percent of the citrus acreage; (2) Cameron County with about 11 percent; and (3) Willacy County with about 3 percent. This acreage is almost evenly divided between oranges and grapefruit.

Research by the Texas Agricultural Extension Service indicated that the most profitable variety of citrus in Texas is the Ruby Red grapefruit. This variety of grapefruit for the 3 seasons from 1968-69, 1969-70, and 1970-71 had an average value of \$8.10 per ton more than oranges. In addition to financial advantages, grapefruit will usually produce more fruit per acre than oranges. 2/

In the 1971-72 season, Texas produced 5.8 million boxes of oranges which was 3.0 percent of the total U.S. orange production and placed Texas a distant third behind Florida and California. The value of this orange production was about \$12.0 million which was about 2.2 percent of the U.S. total of \$550.1 million. In the 1971-72 season Texas produced 9.2 million boxes of grapefruit, or 14.4 percent of the total U.S. production of grapefruit and ranked second in production only to Florida. The value of this Texas grapefruit production was \$20.3 million which was about 11.2 percent of the total value of U.S. grapefruit production of \$181.9 million. 3/

United States foreign trade of citrus shows a definitely favorable surplus of exports over imports and is a factor in helping the United States attain and keep a favorable balance of international trade. The U.S. exports of oranges totaled 8.1 million boxes in 1971 and exceeded orange imports in value by about \$20 million. Grapefruit exports totaled 2.7 million boxes which was an excess of about \$7.5 million of exports over imports. International trade of U.S. citrus produced a surplus of about \$27 million. 3/

2/ Reichart, Alan W. Estimated Costs and Returns for Texas Citrus: Establishment, Development, and Production. Texas Agricultural Extension Service, October 1971.

3/ Agricultural Statistics 1973, USDA.

The demand for citrus grown in Texas has had a definite increase. This change in demand (not to be confused with solely a change in quantity demanded) is clearly illustrated by sales of oranges, which rose from 4.2 million boxes in 1969-70 to 5.8 million boxes in 1971-72. This is a rise of 38.1 percent. At the same time the price of oranges rose 47.9 percent from \$1.40 per box to \$2.07 per box. Grapefruit had a similar increase in demand with sales rising from 8.1 million boxes in 1969-70 to 9.2 million boxes in 1971-72, a 13.6 percent increase, and price rising 41.7 percent from \$1.56 per box to \$2.21 per box. ^{3/} This increase in the quantity demanded coupled with an increase in price between the periods illustrates the concept that demand curves are in constant motion and changing over time. Changes in consumer tastes and preferences and increases in disposable income are primarily responsible for this increasing demand for Texas citrus.

The harvesting of citrus in Texas usually begins in the fall, extends through the winter and ends in late spring or early in the summer. In Texas there is virtually no mechanical harvesting and all fruit is picked by hand. Research is being conducted at the University of California (Riverside) to optimize procedures and systems in the hand harvesting of citrus. This is an effort to make hand picking more efficient and not to replace it with mechanized harvesting.

This report concerns research on the three principal systems of harvesting grapefruit in Texas. These systems are:

- 1 and 1A--pallet bins are filled in the grove, forklift tractor placed the bins onto flat-bed trucks that transport them to the plant, and bins unloaded at the plant with a forklift truck (fig. 1).



Figure 1.--Pallet bins (Systems 1 and 1a) are loaded onto the field truck by the forklift-equipped tractor.

2 and 2A--hoppers of bulk trucks are filled in the grove, the trucks driven to the plant, and the grapefruits dumped onto a conveyor at the plant (fig. 2).



Figure 2.--Picker emptying his canvas filled bag into the bulk hopper truck (Systems 2 and 2A).

3 and 3A--field boxes are filled in the grove, loaded by hand on flat-bed field trucks, strapped down, transported to the plant, and unloaded by hand (fig. 3).



Figure 3.--Field boxes of grapefruit are moved from the field truck (Systems 3 and 3A) into storage using a handtruck.

In all three systems the harvesting operation is done under contract where the harvester is paid an agreed upon flat amount per ton of fruit harvested. The harvester provided the labor and equipment needed to harvest the fruit and also delivered the fruit to the packing plant. The costs for these systems are calculated on a contractual basis and on an hourly basis as though the harvesting foreman's workers were employed by the packing plant. The inputs and costs to the packing plant to harvest, load, transport, unload and store citrus are to be examined.

PROCEDURE

The systems for harvesting citrus in Texas were analyzed in studies to measure labor, materials, and equipment requirements and costs incurred by the packing plants. These were measured in man-hours, equipment-hours, and dollars per function performed. The labor man-hour requirements were converted to costs using the prevailing wage rates for these job categories as reported by the packing plants. The legal minimum wage in Texas in 1975 (\$1.60 per hour)

was paid to all involved employees and 20 percent allowance for fringe benefits, administrative costs, and overhead was added to this hourly wage for all labor cost calculations. The equipment-hour requirements were converted to costs by using hourly ownership and operating costs developed in the appendix of this report.

The studies were conducted in various groves associated with three packing plants. Each of these plants exclusively used one of the harvesting systems studied. Because of the close relationship between plant layout and harvesting system, it is not feasible to combine harvesting systems in a particular packing plant.

To measure the harvesting operations with consistency, it was necessary to determine when the post-harvest movement to the plant was terminated and the storage at the packing plant began.

For the purposes of this study, the harvesting operation ended when the citrus fruit was removed from the truck and placed in storage. (This included reloading fruit into pallet bins to allow it to be placed in storage in Systems 2 and 2A.

In Systems 1 and 1A, pallet bins were filled in the field and the fruit was handled in these bins throughout the total harvesting system. These bins have outside dimensions of 45 by 45 by 29 inches and weigh about 130 pounds. They are made of 5/8-inch, 5-ply, plywood with three equally spaced 3 by 4 by 45-inch bottom runners. The bins come from the manufacturer unassembled and are assembled at the packing plant by shed personnel. In Systems 2 and 2A, the citrus was brought in bulk to the shed, unloaded onto a conveyor, washed, sorted, and graded, and transferred to 47- by 47- by 22-inch pallet bins for storage. The costs for these pallet bins was charged to the harvesting operation for this operation's proportionate share of the use of these bins in a manner similar to that used for Systems 1 and 1A.

In Systems 3 and 3A, field boxes were filled in the field and handled in these boxes throughout the entire system. These boxes have outside dimensions of approximately 15 by 13 by 33 inches and weigh about 17 pounds.

The labor and equipment requirements to unload the trucks for all three systems were measured at the packing plants. These data were converted to labor and equipment costs using the prevailing wage rate and ownership and operating costs developed in the appendix.

At the time these studies were conducted the prevailing contract rate for grapefruit delivered to the plant was \$9 per ton, but it was a general opinion that this rate would soon rise to \$12 per ton. The projected higher rate was used in this report in anticipation of its increase.

Labor and equipment requirements for harvesting were measured and converted to costs using the equipment costs developed in the appendix and the minimum wage plus the 20-percent allowance. These are presented for each system in a separate section so that a comparison could be made between actual costs to the packing plant and costs to the plant if the harvesting foreman's contractual services were not available and had to be provided entirely by the

plant.

For each harvesting system, a model was constructed that included a typical size load, labor requirements, equipment requirements, and costs. For facility in analysis only one product, grapefruit, was used in constructing the models. Other requirements and costs presented in the results were calculated specifically for grapefruit but virtually all of these are applicable to oranges with slight modifications. The component and total system costs for the models are compared in a separate section.

Contract Systems

The contract harvesting systems investigated include grapefruits harvested and handled in pallet bins, bulk trucks, and field boxes. Harvesting was completed under a formal contract between the packing plant and the harvesting foreman. The foreman provides all harvesting labor and the necessary equipment plus transport of the fruit to the plant for a fixed rate per ton.

In all the harvesting systems, the actual picking of the fruit from the tree was the same. The picker, equipped with a canvas harvesting bag, walked around the base of the tree picking all fruit that could be reached from ground level. Then, a ladder was placed against the tree so the picker could reach the remaining fruit. After the bag was filled, the fruit was dumped into either a pallet bin, a bulk hopper truck, or a field box.

The standard practice for harvesting in the Rio Grande Valley involves a harvesting foreman who works under a formal contract with the packing plant. This harvesting foreman provides the pickers, picking bags, ladders, field forklift truck operator and fuel, truck, driver and delivery of full pallet bins to the packing shed. Also, the foreman must give the plant assurance that the pickers will receive at least the legal minimum wage. The packing plant agrees to provide for the unloading of the truck and to pay the harvesting foreman \$12 (anticipated) per ton for grapefruit. The packing plant provides the fruit, pallet bins, field forklift truck (at a charge of \$1 per delivered ton) and forklift trucks and operators at the plant.

System 1 - Pallet Bin

In the pallet bin system, when the bag is full the fruits are emptied into a plywood pallet bin. A tractor equipped with a forklift placed the filled pallet bins on a flat-bed truck which transported them to the packing plant. At the plant a pair of forklift trucks unloaded these bins from the truck (fig. 4) and moved them to a storage area within the packing plant.

The harvesting foreman used a flat-bed truck to haul full pallet bins to the packing plant and to return empty bins to the grove for filling. The size payload observed varied from 14 to 24 bins per truckload with an average of about 20 bins. Packing plant records confirmed that a 20-bin truckload was average.



Figure 4.--Pallet bins (Systems 1 and 1A are unloaded from the field truck by forklifts and are moved directly into storage.

At the packing plant two forklift trucks unloaded the full pallet bins two at a time. The full bins were moved approximately 150 feet from the truck to the storage area in the plant. Each forklift truck made five trips for a total adjusted time of 11.166 man-and equipment-minutes for the two forklift trucks and operators. The field truck was loaded by the same forklift trucks with empty pallet bins and returned to the citrus grove. The two forklift trucks and drivers took a total adjusted time of 10.201 man- and equipment-minutes, to load the field truck with empty pallet bins for return to the field. There were no appreciable delays in this operation. The forklift trucks and drivers went back to their specific jobs within the plant after completing this unloading and loading of empty pallet bins onto the truck.

A sample of 100 full bins was taken and the average weight of the fruit excluding the bin was 847.7 pounds per bin. For ease of calculation 850 pounds per bin was used for the model. This gave a model truckload of 17,000 pounds or 8.5 tons of harvested citrus delivered to the packing plant.

Each truckload consisted of 20 filled pallet bins being brought to the plant and 20 empty bins being returned to the grove for a total of 40 bins per round trip. Each field truck and crew accounted for about two full loads per day. Therefore, the cost of the 40 pallet bins involved in each round trip is calculated over 4 hours for each truckload of citrus delivered to the plant.

The packing plant provided the forklift equipped tractor to handle the pallet bins in the grove, but the harvesting foreman provided the driver and fuel to operate this piece of equipment. The harvesting foreman pays \$1.00

per delivered ton for the use of this field forklift truck. On the model truckload of 8.5 tons this amounts to \$8.50. Once the bins were filled in the grove the field forklift truck took an average of 30.786 minutes to load the 20 bins onto the field truck for delivery to the plant. This field forklift truck was used to move empty and partly full bins through the grove during harvesting.

The disassembled bin was shipped to the packing plant at a purchase price of \$36.00 and required 4 man-hours to assemble. Using a wage rate of \$1.92--\$1.60 minimum wage (Texas) plus 20 percent for fringe benefits, administrative costs and overhead--the total cost to the packing plant was \$43.68 per bin.

The model for this system of harvesting grapefruits using pallet bins has the following characteristics:

- (1) 20-bin truckload.
- (2) 850 pounds of fruit per bin.
- (3) 17,000 pound truckload.
- (4) 11.166 man-minutes and 11.166 equipment-minutes to unload full bins and place in storage at the plant.
- (5) 10.201 man-minutes and 10.201 equipment-minutes to load the truck with empty bins.
- (6) 40 bins handled per round trip. Average time of 4 hours for each trip.
- (7) \$12 per ton paid by packing plant to harvesting foreman.
- (8) \$1 per ton charge for use of field forklift truck.

System 2 - Bulk Truck

In the bulk truck system, when the canvas harvesting bag carried by the picker was filled, the picker climbed a ladder at the side of the bulk truck (fig. 5) and emptied the bag into the bulk hopper of the truck. The bulk truck carried the fruit to the packing plant for unloading (fig. 6). At the shed a sloped unloading ramp allowed the fruit to flow out of the truck onto a conveyor belt (fig. 7) which moved the grapefruit into the plant (fig. 8), through a cleaning operation, and into pallet bins similar to those used in System 1 for storage.

The same type of contractual relationship between harvesting foreman and the packing plant was used in this system as in System 1, except for the fee charged for the use of the field forklift truck.

The harvesting foreman used a flat-bed truck equipped with high wooden sides and rear that formed a hopper into which the fruit was dumped from the harvesting bags. The size payload observed varied from about 14,000 to 24,000 pounds per truckload with an average of 17,967 pounds per truckload. The model truckload size selected was 18,000 pounds or 9.0 tons of harvested citrus delivered to the packing plant by the bulk truck.

At the packing plant the fruit from the full bulk truck was unloaded onto a conveyor, washed, graded, and dumped into pallet bins and placed in the degreening room. One employee at the plant performed the unloading operation.



Figure 5.--Pickers climb ladder to empty citrus into the bulk hopper truck (Systems 2 and 2A).



Figure 6.--Bulk truck (Systems 2 and 2A) waits in line at packinghouse to unload its grapefruit.



Figure 7.--Unloading fruit from bulk truck (Systems 2 and 2A) onto a conveyor to be moved to pallet bins and into storage.



Figure 8.--Grapefruit being moved by roller conveyors from bulk truck to pallet bins for storage.

The total adjusted elapsed time to unload was 20.552 minutes (13.052 minutes plus 7.500 minutes delay between truckloads) for one employee, one conveyor, and 22 pallet bins. These pallet bins were included in the cost of harvesting because both of the other systems provided a storage medium (pallet bins and field boxes) as a part of harvesting. There were no appreciable delays except the approximate 7.5 minutes between unloading one truck and beginning to unload the next.

The model for this system of harvesting grapefruit using bulk trucks has the following characteristics:

- (1) 18,000 pound truckload.
- (2) 20.552 man-minutes and 20.552 equipment-minutes to unload full bulk truck and place in pallet bins for storage.
- (3) 22 pallet bins for each truckload for 0.333 hours each.
- (4) \$12 per ton paid by the packing plant to the harvesting foreman.

System 3 - Field Box

In the field box system, the picker emptied the fruit from his canvas filled bag into a standard field box (fig. 9). These filled boxes were handstacked onto a flat-bed field truck (fig. 10), strapped down, and transported to the packing plant. At the shed, a crew of laborers with handtrucks unloaded the boxes from the truck (fig. 11) and moved them into a storage area in the packing plant.



Figure 9.--Picker dumping his canvas filled bag into field boxes (Systems 3 and 3A).



Figure 10.--Filled field boxes being loaded onto a flat-bed truck in the grove.



Figure 11.--Filled field boxes (Systems 3 and 3A) are stacked five high for unloading and moved into storage with a two-wheel handtruck.

The contract harvester was paid the same (\$12 for grapefruit) per ton of delivered fruit as in Systems 1 and 2. In this system a slightly different method of payment was used, the pickers were paid by the plant per boxful picked and the contract harvester received the amount remaining from the previously mentioned fee.

The harvesting foreman used a flat-bed truck to transport full field boxes to the packing plant and to return empty boxes to the grove. The size payload observed in the study, in conjunction with plant records, showed that the average truckload was about 205 boxes.

A sample of over 400 full field boxes was taken and the average weight of the fruit excluding the box was 71.7 pounds per boxload or 14,698 pounds per model truckload. The model truckload size selected was 14,700 pounds or 7.35 tons of harvested citrus, delivered to the plant.

At the packing plant the full field boxes were unloaded five at a time by two laborers with handtrucks. A man on the truck used an iron rod to separate the columns of five boxes to facilitate the unloading. The full field boxes were moved approximately 30 feet from the truck to the storage area in the plant. Each laborer with a handtruck made over 20 trips for a total adjusted time of 50.082 man-minutes for the three laborers and 33.389 equipment-minutes for the two handtrucks. The harvesting foreman's crew loaded the empty field boxes onto the flat-bed truck (fig. 12) for return to

the grove. The plant provided none of its labor for this operation.



Figure 12.--The contractor harvester's crew loaded the empty field boxes onto the flat-bed truck for return to the grove (Systems 3 and 3A).

Each truckload consisted of 205 full field boxes being brought to the plant and 205 empty boxes being returned to the grove. Each field truck and crew accounted for about two full loads per day, which means that 410 field boxes were handled for each trip from plant to grove and return for an elapsed time of 4 hours per round trip.

The model for this system of harvesting grapefruits has the following characteristics:

- (1) 205-box truckload.
- (2) 14,700-pound truckload (7.35 tons).
- (3) 50.082 man-minutes and 33.389 equipment-minutes to unload full field boxes and place in storage at the plant.
- (4) 410 field boxes handled per round trip.
- (5) Round trip time was 4 hours.
- (6) \$12 per ton paid by the packing plant to the harvesting foreman.

PLANT-EMPLOYED SYSTEMS

In these synthesized plant-employed systems the packing plants employed

all harvesting labor directly. The labor and equipment requirements were measured, and the costs for harvesting and handling citrus in pallet bins, bulk trucks, and field boxes were calculated. These synthesized systems show what the harvesting costs would be if the formal contract system, in use now, did not exist.

System 1A - Pallet Bin

In this synthesized system all harvesting, loading, transporting and unloading operations are the same as in System 1. Labor and equipment requirements were measured and converted to costs using the prevailing wage rate in Texas and ownership and operating costs developed in the appendix.

One picker used 3.115 minutes to pick the fruit and fill his bag, 0.302 minutes to move his filled bag to the pallet bin and dump his bag, and 0.185 minutes to return to the tree and resume picking, for a total productive time of 3.602 man-minutes per bag. Using a 20-percent fatigue allowance because of the strenuous nature of this particular job, the total labor requirements per bag picked are 4.322 man-minutes. An average of 14 full bags with a labor requirement of 60.508 man-minutes (1.009 man-hours) was required to fill one bin. With a 20-bin truckload the labor requirements for picking the fruit and filling the pallet bins were 26.906 man-hours (includes forklift driver and truck driver). The average crew observed consisted of six pickers, one forklift tractor driver, and one truck driver. If these men were employed by the packing plant, a crew chief or supervisor would have to be added to this crew. An additional labor requirement of 3.363 man-hours would be needed for this supervisor.

Under this system the packing plant would have to provide the pickers with the forklift tractor, flat-bed truck, 6 ladders, 6 field bags, and 20 pallet bins each for 3.363 hours per truckload.

Once loaded with filled pallet bins the truck is driven to the packing plant and the full bins are unloaded. The empty bins are then loaded on the truck and returned to the grove. The trip required 0.650 hours to the plant, 0.186 hours to unload, 0.170 hours to load, and 0.650 hours to return. A total of 1.656 equipment-hours were required for the flat-bed truck, 0.828 equipment-hours for the necessary pallet bins, and 1.656 man-hours for the truck driver.

The unloading of filled pallet bins and loading of empties are exactly the same as in System 1.

The model for this system of harvesting grapefruits using pallet bins has the following characteristics:

- (1) 20-bin truckload.
- (2) 850 pounds of fruit per bin.
- (3) 17,000 pound truckload.
- (4) 20.180 man-hours to pick fruit and fill bins.
- (5) 3.363 man-hours each per truckload for the forklift tractor driver, truck driver, and supervisor.

- (6) 3.363 equipment-hours each per truckload for the fork-lift tractor, flat-bed truck, 6 ladders, 6 field bags and 20 pallet bins.
- (7) 1.656 equipment-hours for the flat-bed truck, 0.828 equipment-hours for 40 pallet bins, and 1.656 man-hours for the truck driver for each round trip.
- (8) 11.166 man-minutes and 11.166 equipment-minutes to unload full bins and place in storage at the plant.
- (9) 10.201 man-minutes and 10.201 equipment-minutes to load the truck with empty bins.

System 2A - Bulk Truck

In this synthesized system all harvesting, loading, transporting, and unloading operations are the same as in System 2. Labor and equipment requirements were measured and converted to costs using the prevailing wage rate in Texas and ownership and operating costs developed in the appendix table 6.

An individual picker used 3.115 minutes to pick the fruit and fill his bag, 0.437 minutes to carry his full bag to the bulk truck, climb the ladder and unload his bag, and 0.340 minutes to return to the tree and resume picking, for a total productive time of 3.892 man-minutes per bag. Using a 20-percent fatigue allowance, the total labor requirements per bag picked are 4.670 man-minutes. An average of 300 full bags with a labor requirement of 26.686 man-hours (including truck driver) was required to fill one bulk truck.

The average crew observed consisted of 11 pickers and 1 truck driver. If these men were employed by the packing plant, a crew chief or supervisor would be added to this crew. An additional labor requirement of 3.336 man-hours would be needed for supervision.

Under this system the packing plant would have to provide the pickers with the truck with a hopper body, 11 ladders, and 11 field bags each for 3.336 equipment-hours per truckload.

Once loaded the bulk truck is driven to the packing plant and the fruit is unloaded onto a conveyor. The truck then returns to the grove. The trip required 0.650 hours to the plant, 0.343 hours to unload, and 0.650 hours to return. A total of 1.643 equipment-hours were required for the truck and 1.643 man-hours for the truck driver.

The unloading of the bulk truck and loading of bins at the plant are exactly the same as in System 2.

The model for this system of harvesting grapefruits using bulk trucks has the following characteristics:

- (1) 18,000 pound truckload.
- (2) 26.686 man-hours to pick fruit and fill bulk truck.
- (3) 3.336 man-hours each per truckload for the supervisor.
- (4) 3.336 equipment-hours each per truckload for the truck

- with hopper body, 11 ladders, and 11 field bags.
- (5) 1.643 equipment-hours for the truck and 1.643 man-hours for the truck driver for each round trip.
 - (6) 20.552 man-minutes and 20.552 equipment-minutes to unload full bulk truck and place in pallet bins for storage.
 - (7) 22 pallet bins for each truckload for 0.333 hours each.

System 3A - Field Box

In this synthesized system all harvesting, loading, transporting, and unloading operations are the same as in System 3. Labor and equipment inputs were measured and converted to costs using the prevailing wage rate in Texas and ownership and operating cost developed in the appendix.

One picker used 3.115 minutes to pick the fruit and fill his bag, 0.241 minutes to move his filled bag to the field boxes and unload his bag, and 0.141 minutes to return to the tree and resume picking, for a total productive time of 3.497 man-minutes per bag. Using a 20-percent fatigue allowance, the total labor requirements per bag picked are 4.196 man-minutes. An average of 1 full bag per field box and 205 field boxes per truckload yielded a labor requirement 16.448 man-hours per truckload for harvesting.

A crew of nine men (four on the truck, four on the ground and a truck driver) loaded the filled boxes on a flat-bed truck that is driven through the grove. The men lift the boxes onto the truck and stack them. Loading the truck required a total labor requirement of 2.559 man-hours.

The average crew observed consisted of eight pickers who also loaded the truck with full field boxes and one truck driver. If these men were employed by the packing plant, a supervisor would be added to this crew. A total time of 2.112 man-hours would be used by this supervisor.

Under this system the packing plant would have to provide the pickers with the flat-bed truck, 8 ladders, 8 field bags, and 205 field boxes each for 2.112 equipment-hours per truckload.

Once loaded with filled field boxes the truck is driven to the packing plant and the full field boxes unloaded. The empty field boxes are then loaded, and returned to the grove. The trip required 0.650 hours to the plant, 0.835 hours to unload, 2.000 hours to load empty boxes, and 0.650 hours to return. A total of 4.135 equipment-hours were required for the flat-bed truck and 205 field boxes and 8.270 man-hours for the truck driver and one other man.

The unloading of filled field boxes is exactly the same as in System 3.

The model for this system of harvesting Texas citrus using field boxes has the following characteristics:

- (1) 205-box truckload.
- (2) 14,700-pound truckload (7.35 tons).

- (3) 16.448 man-hours to pick fruit and fill boxes.
- (4) 2.559 man-hours to load the truck in the grove.
- (5) 2.112 man-hours per truckload for the supervisor.
- (6) 2.112 equipment-hours each per truckload for the flatbed truck, 8 ladders, 8 field bags, and 205 field boxes.
- (7) 4.135 equipment-hours for the flatbed truck and 205 field boxes, and 8.270 man-hours for the truck driver and assistant for each round trip.
- (8) 50.082 man-minutes and 33.389 equipment-minutes to unload full field boxes and place in storage at plant.

COST COMPARISON OF MODELS

Harvesting costs for the three contract harvesting systems are presented in table 1. In these systems a contract fee of \$12 per ton of grapefruit harvested and delivered to the packing plant was used instead of the present fee of \$9 a ton, in anticipation of an expected increase in the harvesting fee. The harvesting costs per ton for System 1 (pallet bins) is \$0.08 less than for Systems 2 (bulk trucks) or 3 (field boxes). This slight difference is because the packing plant is charging the contract harvester slightly more than our calculated costs for the forklift tractor.

Harvesting labor requirements and transporting costs of grapefruits for the three synthesized plant-employed harvesting systems are presented in table 2. System 2A (bulk trucks) had harvesting labor costs that were \$0.50 per ton less than System 1A (pallet bins) and \$0.76 per ton less than System 3A (field boxes). System 2A had almost identical total costs per truckload as System 1A with the difference per ton coming from a 1,000 pound larger payload for System 2A. System 3A was so much higher per ton because of the large man-hour requirements to drive to the plant and to load the truck with empty field boxes after unloading by plant personnel.

Harvesting costs and transporting equipment costs of grapefruits for three synthesized plant-employed harvesting systems are shown in table 3. System 2A had equipment costs for the harvesting and transporting operation that were \$1.20 per ton less than System 3A and \$1.23 per ton less than System 1A. System 2A (bulk trucks) with a total labor and equipment cost of \$9.91 per ton was \$1.73 per ton less costly than System 1A (pallet bins) and \$1.96 per ton less costly than System 3A (field boxes).

The costs for handling grapefruits at the packing plant in pallet bins (Systems 1 and 1A), in bulk trucks (Systems 2 and 2A) and in field boxes (Systems 3 and 3A) and loading empty bins and boxes are presented in table 4. Systems 2 and 2A had labor and equipment costs of \$0.19 per ton, which were \$0.20 per ton less than Systems 1 and 1A and were \$0.48 per ton less than Systems 3 and 3A. Because no empty bins or boxes had to be loaded for return to the grove, the bulk truck (Systems 2 and 2A) had substantially lower costs than the other systems which provided labor and equipment to load the truck with empty containers for use in the grove.

Total costs for the six systems are presented in table 5. Of the three contract systems System 2 (bulk trucks) had the lowest total system cost at \$12.19 per ton which was a savings of \$0.12 per ton over System 1 (pallet bins) which cost \$12.31 per ton and of \$0.48 per ton over System 3 (field boxes) which cost \$12.67 per ton. Of the three synthesized plant-employed systems System 2A also had the lowest total system cost at \$10.10 per ton which was \$1.93 per ton less than System 1A at \$12.03 per ton and \$2.44 per ton less than System 3A at \$12.54 per ton. These total costs indicate that the costs for harvesting and transporting to the plant are virtually the same for Systems 1 and 1A and Systems 3 and 3A using the contract system as is presently being used rather than employing all of the harvesting labor directly and providing the necessary equipment. For the bulk truck systems (2 and 2A) there is an indication that substantial savings may be possible if the packing plant employed the harvesting crews and provided them with the necessary equipment.

Table 1.--Harvesting and transporting costs of grapefruits for three contract harvesting systems

System	Size of load <u>1/</u>	Gross costs of harvesting and transporting				Harvesting cost per ton
		Contract fee <u>2/</u>	Less: Field equipment fee <u>3/</u>	Cost of field equipment <u>4/</u>	Total	
	<u>Pounds</u>	<u>Dollars</u>	<u>Dollars</u>	<u>Dollars</u>	<u>Dollars</u>	<u>Dollars</u>
1 - Pallet bins	17,000	102.00	8.50	7.80	101.30	11.92
2 - Bulk trucks	18,000	108.00	-	-	108.00	12.00
3 - Field boxes	14,700	88.20	-	-	88.20	12.00

1/ For System 1 a truckload of 20 bins, 850 pounds of fruit per bin, 17,000 pound net total was used as the model. For System 3 a truckload of 205 boxes, 71.7 pounds of fruit per box, 14,700 pound net total was used as the model.

2/ Contract fee paid at \$12 per ton for grapefruit (anticipated cost).

3/ At \$1 per ton for use of field equipment.

4/ Based on 4 hours per truckload and \$1.95 per hour for forklift equipped tractor (table 3).

Table 2.--Harvesting labor requirements and transporting costs of grapefruits for three synthesized plant-employed systems

System	Size of load Pounds	Labor requirements and costs						Total labor cost Dollars	Labor cost per ton Dollars
		Harvesting labor		Harvesting supervisions		Transporting			
		Requirements	Costs 1/ Dollars	Requirements	Costs 2/ Dollars	Requirements	Costs Dollars		
			Man-hours		Man-hours		Man-hours		
1A - Pallet bins	17,000	26.906	51.66	3.363	12.91	1.656	3.18	67.75	7.97
2A - Bulk trucks	18,000	26.686	51.24	3.336	12.81	1.643	3.15	67.20	7.47
3A - Field boxes	14,700	19.007	36.50	2.112	8.11	8.270	15.88	60.49	8.23

1/ Wage rate for laborers at \$1.60 per hour plus 20 percent for fringe.

2/ Wage rate for supervisors at \$3.20 per hour plus 20 percent for fringe.

Table 3.--Harvesting and transporting equipment costs for three synthesized plant-employed harvesting systems for grapefruit 1/

System	Size of load Pounds	Equipment costs				Total equipment costs per ton			
		Ladders	Field bag	Pallet bins	Field boxes	Total equipment costs	Equipment costs per ton		
		Costs Dollars	Costs Dollars	Costs Dollars	Costs Dollars	Costs Dollars	Costs Dollars		
1A - Pallet bins	17,000	2/ 0.12	2/ 1.13	2/ 0.81	-	31.21	3.67		
2A - Bulk trucks	18,000	3/ 0.14	3/ 1.31	-	-	22.00	2.44		
3A - Field boxes	14,700	4/ 0.10	4/ 0.95	-	4/ 0.87	26.77	3.64		

1/ Hourly ownership and operating costs developed in appendix.

2/ Equipment-hour requirements per truckload for system 1A were 3.363 for the forklift tractor, 5.019 for the truck, 20.178 for the ladders, 20.178 for the field bags, and 100.380 for the pallet bins.

3/ Equipment-hour requirements per truckload for system 2A were 4.979 for the truck, 23.352 for the ladders, and 23.352 for the field bags.

4/ Equipment-hour requirements per truckload for system 3A were 6.247 for the truck, 16.896 for the ladders, 16.896 for the field bags, and 432.960 for the field boxes.

Table 4.--Labor and equipment requirements and costs for handling grapefruit at the packing plant for contract and plant-employed systems

Systems	Size of load 1/	Labor requirements	Labor costs 2/	Equipment costs 3/	Total labor and equipment costs	Total labor and equipment cost per ton
	<u>Pounds</u>	<u>Man-hrs.</u>	<u>Dollars</u>	<u>Dollars</u>	<u>Dollars</u>	<u>Dollars</u>
1 and 1A - Pallet bins	17,000	0.356	0.68	4/ 2.65	3.33	0.39
2 and 2A - Bulk trucks	18,000	.348	.67	5/ 1.05	1.72	0.19
3 and 3A - Field boxes	14,700	.835	1.60	6/ 3.31	4.91	0.67

1/ See table 1.

2/ Based on an hourly rate of \$1.60 plus 32 cents fringe benefits, or \$1.92 per hour.

3/ Equipment costs for table 3.

4/ Equipment-hour requirements per truckload for systems 1 and 1A were 0.356 for the forklift tractor and 160.0 for pallet bins.

5/ Equipment-hour requirements per truckload for systems 2 and 2A were 11.0 for pallet bins and 0.343 for the conveyor and unloading facilities.

6/ Equipment-hour requirements per truckload for system 3 and 3A were 1640.0 for field boxes, 0.557 for handtrucks and 0.557 for the dockplate.

Table 5.--Labor, equipment and total costs for 6 systems of harvesting of grapefruits with contract crews and plant-employed crews

System	Size of load <u>Pounds</u>	Harvesting and transporting costs			Handling costs at the plant			Total system costs	
		<u>Labor Dollars</u>	<u>Equipment Dollars</u>	<u>Total Dollars</u>	<u>Labor 1/ Dollars</u>	<u>Equipment 1/ Dollars</u>	<u>Total Dollars</u>	<u>Total system costs per ton Dollars</u>	
Contract Systems:									
1 - Pallet bins	17,000	-	-	2/ 101.30	0.68	2.65	3.33	12.31	
2 - Bulk trucks	18,000	-	-	2/ 108.00	0.67	1.05	1.72	12.19	
3 - Field boxes	14,700	-	-	2/ 88.20	1.60	3.31	4.91	12.67	
Plant-Employed Systems:									
1A - Pallet bins	17,000	3/ 67.75	4/ 31.21	98.96	0.68	2.65	3.33	12.03	
2A - Bulk trucks	18,000	3/ 67.20	4/ 22.00	89.20	0.67	1.05	1.72	10.10	
3A - Field boxes	14,700	3/ 60.49	4/ 26.77	87.26	1.60	3.31	4.91	12.54	

1/ Refer to table 4.

2/ Refer to table 1.

3/ Refer to table 2.

4/ Refer to table 3.

APPENDIX
Table 6.--Hourly ownership and operating costs for equipment required for six systems of harvesting grapefruits

System and equipment	Initial cost	Total fixed costs		Power 2/	Main-tenance 3/	Total variable costs		Total annual costs	Costs per hour of operation 4/
		Dollars	Dollars 1/			Dollars	Dollars		
<u>System 1 - Pallet bins:</u>									
Forklift truck	11,000.00 (8)	2,145.00		550.00	165.00	715.00	2,860.00	2.043	
Field forklift tractor	13,000.00 (8)	2,535.00		-	195.00	195.00	2,730.00	1.950	
Pallet bin	43.68 (4)	13.98		-	5/ 2.23	2.23	16.21	.012	
<u>System 2 - Bulk trucks:</u>									
Pallet bin	43.68 (8)	8.52		-	5/ 2.23	2.23	10.75	.008	
Conveyor-motorized	4,800.00 (8)	936.00		204.00	72.00	276.00	1,212.00	.866	
Facilities for unloading	20,000.00 (20)	2,400.00		-	300.00	300.00	2,700.00	1.929	
<u>System 3 - Field boxes:</u>									
Field box	6.00 (6)	1.42		-	6/ 1.50	1.50	2.92	.002	
Hand trucks	75.00 (12)	11.50		-	1.13	1.13	12.63	.009	
Dockplate	300.00 (10)	51.00		-	4.50	4.50	55.50	.040	
<u>System 1A - Pallet bins:</u>									
Field forklift tractor	13,000.00 (8)	2,535.00		650.00	195.00	845.00	3,380.00	2.414	
Flat-bed truck	8,500.00 (4)	2,720.00		7/ 2,000.00	8/ 850.00	2,850.00	5,570.00	3.979	
Pallet bin	43.68 (8)	8.52		-	5/ 2.23	2.23	10.75	.008	
Ladder	15.00 (2)	8.55		-	-	-	8.55	.006	
Picking bag	12.50 (.08)	12/ 13.37		-	-	-	9/ 13.37	.056	
<u>System 2A - Bulk trucks:</u>									
Flat-bed truck with hopper sides	9,000.00 (4)	2,880.00		7/ 2,000.00	8/ 900.00	2,900.00	5,780.00	4.129	
Ladder	15.00 (2)	8.55		-	-	-	8.55	.006	
Picking bag	12.50 (.08)	12/ 13.37		-	-	-	9/ 13.37	.056	
<u>System 3A - Field boxes:</u>									
Flat bed truck	8,500.00 (4)	2,720.00		7/ 2,000.00	8/ 850.00	2,850.00	5,570.00	3.979	
Ladder	15.00 (2)	8.55		-	-	-	8.55	.006	
Picking bag	12.50 (.08)	12/ 13.37		-	-	-	9/ 13.37	.056	
Field box	6.00 (6)	1.42		-	6/ 1.50	1.50	2.92	.002	

1/ Total fixed costs include straight-line depreciation (estimated life in years in parenthesis after initial cost), interest at 3 percent of initial cost or 6 percent of depreciated balance, and insurance and taxes at 4 percent of initial costs.

2/ Power costs for gas powered at 5 percent of initial costs.

3/ Maintenance costs at 1.5 percent of initial costs.

4/ Based on 1400 hours of annual operation for all equipment except picking bags which have 240 hours of use per month.

5/ Annual maintenance cost per pallet bin taken from packing plant records.

6/ Estimated by the citrus association.

7/ Fuel costs calculated at \$250 per month for 8 months of operation per year.

8/ Maintenance costs at 10 percent of initial costs.

9/ Monthly figures.

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